

Ghosts, Vampires and Zombies

Cinema Fiction vs Physics Reality

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Abstract

We examine certain features of popular myths regarding ghosts, vampires and zombies as they appear in film and folklore. We use physics to illuminate inconsistencies associated with these myths and to give practical explanation to certain aspects.

1 Introduction

Perhaps for many, ghosts, vampires, zombies and the like are no more than Hollywood fantasy. However, increasingly these movies have come to reflect popularly held pseudoscientific beliefs. For instance, the movie “White Noise,” starring Michael Keaton, is based on the new trend among paranormalists — Electronic Voice Phenomena (EVP). The occult underground in both America and Europe is witnessing a trendy rise in vampirism and belief in voodoo zombieification which is widespread in many parts of South America and Africa. Further, paranormal depictions in the media, especially television and Hollywood, have a definite influence on the way people think about paranormal claims ([Sparks 1998, Sparks 2006] and references therein).

In this article we point out inconsistencies associated with the ghost, vampire and zombie mythologies as portrayed in popular films and folklore, and give practical explanations to some of their features. We also use the occasion as an excuse to teach a little about physics and mathematics.

Of course the paranormalist or occultist could claim that the Hollywood portrayal is a rather unsophisticated and inaccurate representation of their beliefs, and thus the discussion we give here is moot. However, if they are to change their definition each time we raise issue, then all that they are really arguing is that there exists something out there which may be given the name ‘ghost’, for instance. Surely, no skeptic could argue with this.

2 Ghosts

2.1 Sudden Colds

It has become almost a Hollywood cliché that the entrance of a ghostly presence be foreshadowed by a sudden and overwhelming chill (see, for example, “The Sixth Sense”, starring Bruce Willis). In fact, sharp temperature drops are very commonly reported in association with supposed real-life encounters with ghosts or poltergeists. This feature of supposed ghost sightings lends itself naturally to physical explanation.

The famous Haunted Gallery at Hampton Court Palace near London, UK, is reputedly stalked by the spirit of Catherine Howard, who was executed on 13 February, 1542, by Henry VIII. Visitors to the room have described hearing screams and seeing apparitions in the gallery. A team of ghost-busting psychologists, led by Dr Richard Wiseman of Hertfordshire University, installed thermal cameras and air movement detectors in the gallery. About 400 palace visitors were then quizzed on whether they

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could feel a “presence” in the gallery. More than half reported sudden drops in temperature and some said they sensed a ghostly presence. Several people claimed to have seen Elizabethan figures.

Before moving on to an explanation, we will need to outline the concept of heat. When a ‘warm’ object is placed next to a ‘cool’ object (see figure 1) energy will begin to flow from the warmer body, causing it to cool, to the cooler body, causing it to warm. This energy, which is being transferred between the two objects due to their difference in temperature, is called *heat*. Note that an object is never said to ‘possess’ any amount of heat. Heat is only defined through transfer. For instance, no matter how high one turns their stove, it never possesses any degree of heat. In the instance where someone suddenly touches the stove, however, there is there occurrence heat — it is the energy flowing from the stove to that person’s hand.

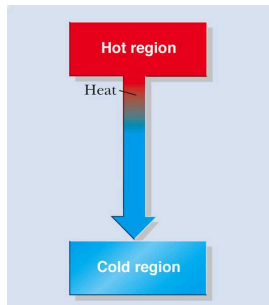


Figure 1: Heat always moves from a hotter object to a colder object. Picture is borrowed from [Kirkpatrick & Francis 2007].

As heat continues to be transferred from the warmer body to the cooler one in figure 1, and the warmer body’s temperature continues to drop while the cooler body’s temperature climbs, there comes a point when the two bodies are at the same temperature. At this point heat ceases to flow between the two object since neither is the hotter one and heat has no definite direction in which to be transferred. This condition is called *thermal equilibrium*.

In our stove example, heat was transferred via *conduction* — the exchange of heat through direct contact. There are two other modes by which heat may be transferred. These two modes involve the exchange of heat by two objects which are separated by some distance. If these two objects are emersed in a fluid (Earth’s atmosphere for example), then the warmer body may provide heat to the fluid in its immediate vicinity. This warmer fluid will then tend to rise thus coming in contact with a cooler body above. There may also be a lateral current in the fluid, thus allowing the heated fluid to affect a cooler body to the side. This type of heat transfer, by an intermediary fluid, is called *convection*.

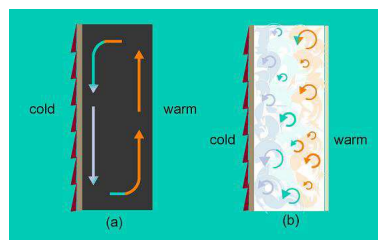


Figure 2: Convection currents in a fluid. Picture is borrowed from [Bolemon].

In figure 2(a) we give an example of what is known as *convection currents*. Suppose that the right wall is kept warm and the left wall is kept cool. Then air in contact with the right wall will tend to gain heat and then rise while air in contact with the left wall will tend to lose heat and then sink. The circular flow that then forms is called a convection current. Air cycles around a loop picking up some heat at the right wall, dropping it off at the left wall, and then coming back around again. Actually, the air current pattern will be somewhat more complicated than what we just described. There will be all kinds of smaller cycles and eddies embedded in some complex pattern as in figure 2(b). The overall flow, however, will be as in figure 2(a).

The third mode of heat transfer allows for exchange between two separated objects even if they are in a total vacuum. How can two objects exchange heat if there is no matter in between them? The answer is *radiation*. The thermal energy of a body is expressed in the ‘jiggling’ of its various constituent particles. As electrically charged particles within a body jiggle about, they produce electromagnetic waves. When these waves hit another body, they cause the particles in that body to jiggle even more than they were before and thus the body heats up. Since hotter bodies produce more of this radiation, there will be more radiation from the hotter body falling upon the cooler body than radiation from the cooler body falling upon the hotter body. Thus, overall, the hotter body will be losing heat while the cooler body will be gaining heat. We will not be too concerned with this particular mechanism for heat exchange here.

Returning to the Haunted Gallery at Hampton Court Palace, Dr Wiseman’s team reported [BBC 2001] that the experiences could be simply explained by the gallery’s numerous concealed doors. These elderly exits are far from draught-proof and the combination of air currents which they let in cause sudden changes in the room’s temperature. In two particular spots, the temperature of the gallery plummeted by up to 2°C (3.6°F). “You do, literally, walk into a column of cold air sometimes,” said Dr Wiseman. “It’s possible that people are misattributing normal phenomena... If you suddenly feel cold, and you’re in a haunted place, that might bring on a sense of fear and a more scary experience.” The rumor that ‘cold spots’ are associated with ghosts seems to be a myth created by the construction of old building and the vivid imagination of people.

But how could a few degrees drop in temperature explain the dramatic chills described so many in ghostly accounts? First off, what we sense as cold is not correlated to temperature so much as to the rate at which heat is being transferred from our body to the environment. For instance, even in a temperate pool, one feels a very sharp chill when one first enters. A moderate draft containing condensed moisture could cause a very sharp sensation of cold. Secondly, we are all aware of the ‘tall-tale’ effect. Memories tend to become distorted and exaggerated. It is exactly this reason why scientists tend not to rely on unchecked eyewitness accounts.

2.2 The Inconsistency of the Notion of Material-lessness

Popular myth holds that ghosts are material-less. For instance in the movie “Ghost” (starring Patrick Swayze, Demi Moore, Whoopi Goldberg), the recently deceased main character tries desperately to save his former lover from a violent intruder. His attempts grant him no avail, as at each lunge he passes right through the perpetrator. It is interesting, however, that he was able to walk up the stairs just previous to this. In fact, this is a common feature of the ghost myth. Ghosts are held to be able to walk about as they please, but they pass through walls and any attempt to pick up an object or affect their environment in any other way leads to material-less inefficacy — unless they are poltergeists, of course!

Let us examine the process of walking in detail. Now walking requires an interaction with the floor and such interactions are explained by *Newton’s Laws of Motion*. Newton’s *first law* is the law of inertia. It states that a body at rest will remain at rest until acted upon by an *external* force.



Figure 3: Two stills taken from the movie “Ghost”. In the left still the ghost goes through a door. In the right still, the ghost — which follows a burglar in his girlfriend’s home — loses his balance as he ascends the staircase and falls on the stairs.

Therefore, a person cannot start walking unless a force, applied by some body other than herself, is acting upon her. But where is the force coming from? The only object in contact with the person while walking is the floor. So, the force moving a person during walking is coming from the floor. But how does the floor know to exert a force when the person wants to start walking and stop exerting it when the person wants to stand? Actually, there is no magic here. The person actually tells the floor. She tells the floor by using Newton’s *third law*.

Newton’s third law says that if one object exerts a force on another object, then the second object exerts a force, that is equal but oppositely directed, on the first object — hence “for each action there is an equal but opposite reaction.” Thus when the skate-boarder in figure 4 pushes on the wall, the wall pushes right back on her, causing her to accelerate off to the left.

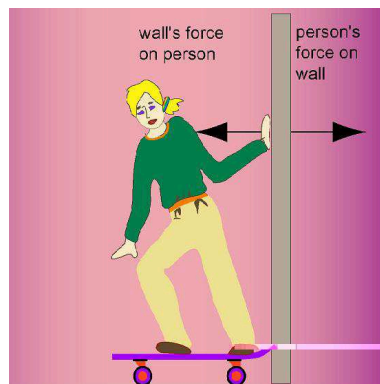


Figure 4: An example of Newton’s third law known as action-reaction law. Picture is borrowed from [Bolemon].

Thus walking goes like this (see figure 5): The person wanting to do the walking must remain at rest unless a force acts on her. She gets the floor to apply a force on her by applying a backward force on the floor with her foot. She keeps repeating this action, alternating feet. The point is that for the ghost to walk, it must be applying forces to the floor. Now the floor is part of the physical universe. Thus the ghost has an affect on the physical universe. If this is so, then we can detect the ghost via physical observation. That is, the depiction of ghosts walking, contradicts the precept that ghosts are material-less.

So which is it? Are ghosts material or material-less? Maybe they are only material when it comes



Figure 5: Forces acting on the feet of a person while walking. Picture is borrowed from [Bolemon].

to walking. Well then we must assume that they can't control this selective material-lessness, otherwise Patrick Swayze would have saved his girlfriend in "Ghost." In this case, we could place stress sensors on the floor and detect a ghost's presence. Maybe they walk by some other supernatural means. Well why can't they use this power to manipulate objects when they want to? Even more, it seems strange to have a supernatural power that only allows you to get around by mimicking human ambulation. This is a very slow and awkward way of moving about in the scheme of things. In any case, you'd have to go to some lengths to make this whole thing consistent.

Incidentally, the reader may have noticed that we skipped a law in our discussion. We heard about the first law and the third law. Newton's second law of motion is that the acceleration of an object — the rate at which it speeds up — is proportional to the force applied, the constant of proportionality being the mass. We didn't need this law for our discussion but mention it for completeness.

3 Vampires

Anyone who has seen John Carpenter's "Vampires" or the movie "Blade" or any of the host of other vampire films is already quite familiar with how the legend goes. The vampires need to feed on human blood. After one has stuck his fangs into your neck and sucked you dry, you turn into a Vampire yourself and carry on the blood sucking legacy. The fact of the matter is, if vampires truly feed with even a tiny fraction of the frequency that they are depicted to in the movies and folklore, then the human race would have been wiped out quite quickly after the first vampire appeared.

Let us assume that a vampire need feed only once a month. This is certainly a highly conservative assumption given any Hollywood vampire film. Now two things happen when a vampire feeds. The human population decreases by one and the vampire population increases by one. Let us suppose that the first vampire appeared in 1600 AD. It doesn't really matter what date we choose for the first vampire to appear; it has little bearing on our argument. We list a government website in the references [US Census] which provides an estimate of the world population for given any date. For January 1, 1600 we will accept that the global population was 536,870,911.³ In our argument, we had at the same time 1 vampire.

We will ignore the human mortality and birth rate for the time being and only concentrate on the effects of vampire feeding. On February 1st, 1600 1 human will have died and a new vampire born. This gives 2 vampires and $(536,870,911 - 1)$ humans. The next month there are two vampires feeding

³It may seem odd to the reader that we have specified the population with so much precision — we have a number in the one-hundred millions and have specified it all the way down to the 'one's place' (...911). We chose the particular value for convenience. The actual estimated population in the 17th century is 562 ± 17 millions. Beyond mathematical simplification, our choice has little impact on the argument to follow. If we were to report any number in the range of possible values for the population in year 1600, the end result of our calculations below would be essentially the same.

Month	Vampire Population	Human Population	Month	Vampire Population	Human Population
1	1	536870911	16	32768	536838144
2	2	536870910	17	65536	536805376
3	4	536870908	18	131072	536739840
4	8	536870904	19	262144	536608768
5	16	536870896	20	524288	536346624
6	32	536870880	21	1048576	535822336
7	64	536870848	22	2097152	534773760
8	128	536870784	23	4194304	532676608
9	256	536870656	24	8388608	528482304
10	512	536870400	25	16777216	520093696
11	1024	536869888	26	33554432	503316480
12	2048	536868864	27	67108864	469762048
13	4096	536866816	28	134217728	402653184
14	8192	536862720	29	268435456	268435456
15	16384	536854528	30	536870912	0

Table 1: Vampire and human population at the beginning of each month during a 29 month period.

and thus two humans die and two new vampires are born. This gives 4 vampires and $(536,870,911 - 3)$ humans. Now on April 1st, 1600 there are 4 vampires feeding and thus we have 4 human deaths and 4 new vampires being born. This gives us 8 vampires and $(536,870,911 - 7)$ humans.

By now the reader has probably caught on to the progression. Each month the number of vampires doubles so that after n months have passed there are

$$\underbrace{2 \times 2 \times \dots \times 2}_{n \text{ times}} = 2^n$$

vampires. This sort of progression is known in mathematics as a *geometric progression* — more specifically it is a geometric progression with ratio 2, since we multiply by 2 at each step. A geometric progression increases at a very tremendous rate, a fact that will become clear shortly. Now all but one of these vampires were once human so that the human population is its original population minus the number of vampires excluding the original one. So after n months have passed there are

$$536,870,911 - 2^n + 1$$

humans. The vampire population increases geometrically and the human population decreases geometrically.

Table 1 above lists the vampire and human population at the beginning of each month over a 29 month period. Note that by month number 30, the table lists a human population of zero. We conclude that if the first vampire appeared on January 1st of 1600 AD, humanity would have been wiped out by June of 1602, two and half years later.

All this may seem artificial since we ignored other effects on the human population. Mortality due to factors other than vampires would only make the decline in humans more rapid and therefore strengthen our conclusion. The only thing that can weaken our conclusion is the human birth rate. Note that our vampires have gone from 1 to 536,870,912 in two and a half year. To keep up, the human population would have had to increase by the same amount. The website [US Census] mentioned earlier also provides estimated birth rates for any given time. If you go to it, you will notice that the

human birth rate never approaches anything near such a tremendous value. In fact in the long run, for humans to survive, our population must *at least* essentially double each month! This is clearly way beyond the human capacity of reproduction.

If we factor in the human birthrate into our discussion, we would find that after a few months, the human birthrate becomes a very small fraction of the number of deaths due to vampires. This means that ignoring this factor has a negligibly small impact on our conclusion. In our example, the death of humanity would be prolonged by only one month.

We conclude that vampires cannot exist, since their existence contradicts the existence of human beings. Incidentally, the logical proof that we just presented is of a type known as *reductio ad absurdum*, that is, reduction to the absurd. Another philosophical principal related to our argument is the truism given the elaborate title, the *anthropic principle*. This states that if something is necessary for human existence, then it must be true since we do exist. In the present case, the nonexistence of vampires is necessary for human existence. Apparently, whomever devised the vampire legend had failed his college algebra and philosophy courses.

4 Zombies

The zombie legends portrayed in movies such as “Dawn of the Dead” or “28 Days Later” follow a similar pattern to the vampire legends. Once you are bitten by zombies, while you may manage to escape immediate death, you will eventually die and turn into a zombie yourself. Thus, this particular type of zombie legend suffers the same flaw that we pointed out for the vampire legend previously. We still have some more work to do, however. There exists a second sort of zombie legend which pops its head up throughout the western hemisphere — the legend of ‘voodoo zombiefication’. This myth is somewhat different from the one just described in that zombies do not multiply by feeding on humans but come about by a voodoo hex being placed by a sorcerer on one of his enemy. The myth presents an additional problem for us: one can witness for them self very convincing examples of zombiefication by traveling to Haiti or any number of other regions in the world where voodoo is practiced.

We describe the particular case of Wilfrid Doricent⁴, an adolescent school boy from a small village in Haiti. One day Wilfred had become terribly ill. He was experiencing dramatic convulsions, his body had swelled tremendously and his eyes had turned yellow. Eight days latter, Wilfred appeared to have died. This was confirmed by not only by the family and family friends present but also by the local medical doctor who could detect no vital signs. Wilfred’s body appeared to show bloating due to rigor-mortis and gave off the foul stench of death and rot. His body was buried soon thereafter.

Some time afterward, the weekly village cock-fight was interrupted as an incognizant figure appeared. The villagers were shocked as they gazed upon the exact likeness of Wilfred. The arrival was indeed Wilfred as his family verified by noting scars from old injuries and other such details. Wilfred, however, had lost his memory and was unable to speak or comprehend anything that was spoken to him. His family had to keep him in shackles so that he wouldn’t harm himself in his incoherent state. It appeared that Wilfred’s body had risen from death leaving his sole in the possession of some voodoo sorcerer. Word of Wilfred’s ‘zombiefication’ spread quickly throughout the village. It was believed that Wilfred’s uncle, a highly feared voodoo sorcerer who had been engaged in a dispute over land with Wilfred’s family, was the culprit. Wilfred’s uncle was later charged with zombiefication, a crime in Haiti equivalent to murder.

Is this truly a case of supernatural magic? To answer this question, we turn our attention to a

⁴We claim no major originality in the presentation of what follows — except in collecting the material from the sources and arranging it as seen. Doricent’s case is nicely described in the documentary [Clark 2002]. The relation between zombies and TTX was first noticed by the Harvard ethnobotanist Wade Davis in 1982.



Figure 6: Wilfrid Doricent, the zombie, with his parents.

highly toxic substance called tetrodotoxin (TTX). Bryan Furlow gives a nice overview [Furlow 2001] of TTX’s effects blended with a headlining news story:

At first the US federal officers thought they had stumbled upon a shipment of heroin. The suspicious package they intercepted last year [2000], en route from Japan to a private address in the US contained several vials packed with a white crystalline powder. But on-the-spot tests revealed that it was no narcotic. It took a while for forensic scientists at the Lawrence Livermore National Laboratory in California to identify a sample, and what they found was alarming. The powder turned out to be tetrodotoxin (TTX): one of the deadliest poisons on Earth.

Gram for gram, TTX is 10,000 times more lethal than cyanide... This neurotoxin has a terrifying modus operandi—25 minutes after exposure it begins to paralyze its victims, leaving the brain fully aware of what’s happening. Death usually results, within hours, from suffocation or heart failure. There is no antidote. But if lucky patients can hang on for 24 hours, they usually recover without further complications...

The Livermore team estimated that to extract the 90 milligrams of TTX discovered by the Feds, you’d need between 45 and 90 kilograms of puffer fish livers and ovaries—the animal’s most deadly tissues. No one knows what use its intended recipient had in mind...



Figure 7: Puffer fish.

TTX is found in various sea creatures and, in particular, in the species of puffer fish. Puffer fish are a delicacy in Japan known as ‘fugu’ where only trained and licensed individuals prepare it by carefully removing the viscera. Of course, despite the care taken in preparation, about 200 cases of puffer fish poisoning are reported per year with a mortality rate 50%. The symptoms of the poisoning are as follows [US FDA]:

The first symptom of intoxication is a slight numbness of the lips and tongue, appearing between 20 minutes to three hours after eating poisonous puffer fish. The next symptom is increasing paraesthesia in the face and extremities, which may be followed by sensations of lightness or floating. Headache, epigastric pain, nausea, diarrhea, and/or vomiting may occur. Occasionally, some reeling or difficulty in walking may occur. The second stage of the intoxication is increasing paralysis. Many victims are unable to move; even sitting may be difficult. There is increasing respiratory distress. Speech is affected, and the victim usually exhibits dyspnea, cyanosis, and hypotension. Paralysis increases and convulsions, mental impairment, and cardiac arrhythmia may occur. The victim, although completely paralyzed, may be conscious and in some cases completely lucid until shortly before death. Death usually occurs within 4 to 6 hours, with a known range of about 20 minutes to 8 hours.

Sometimes however, a victim pronounced dead, is lucky enough to wake up just before his funeral and report to his bewildered family that he was fully conscious and aware of his surroundings throughout the entire ordeal. Therefore, TTX has the unusual characteristic that if a nonlethal dose is given, the brain will remain completely unaffected. If just the right dose is given, the toxin will mimic death in the victim, whose vitals will slow to an immeasurable state, and whose body will show signs of rigor-mortis and produce the odor of rot. Getting such a precise dose would be rare for the case of fugu poisoning, but can easily be caused deliberately by a voodoo sorcerer, say, who could slip the dose into someone's food or drink.



Figure 8: Frère Dodo, ex-voodoo priest, confirms that the recipe used to make the drug for zombieification includes a powder derived from the puffer fish.

The secrets of zombieification are closely guarded by voodoo sorcerers. However, Frère Dodo, a once highly feared voodoo sorcerer who is now an Evangelican preacher and firm denouncer of the voodoo faith, has revealed the process. It turns out that zombieification is accomplished by slipping the victim a potion whose main ingredient is powder derived from the liver of a species of puffer fish native to Haitian waters.

Well, we now have an explanation for how Wilfred could have been made to seem dead, even under the examination of a doctor. However, we have already said that the TTX paralysis was unlikely to have affected his brain. How does one account for Wilfred's comatose mental state? The answer is oxygen deprivation. Wilfred was buried in a coffin in which relatively little air could have been trapped. Wilfred's story probably goes something like this: Slowly, the air in Wilfred's coffin began to run out so that by the time he snapped out his TTX-induced paralysis, he had already suffered some degree of brain damage. At this point his survival instincts kicked in and he managed to dig himself out of his grave — graves tend to be dug shallow in Haiti. He probably wandered around for some time before ending up back at the village.



Figure 9: Brain scan of W. Doricent. The doctor points to lesions in the ventricular system of the right frontal cone.

Neuropsychiatrist Dr. Roger Mallory, of the Haitian Medical Society, conducted an MRI of zombieified Wilfred’s brain. He and his colleagues found lesions of the type normally associated with oxygen starvation. It would seem that zombieification is nothing more than a skillful act of poisoning. The bodily functions of the poisoned person suspend so that he appears dead. After he is buried alive, lack of oxygen damages the brain. If the person is unburied before he really dies from suffocation, he will appear as a soulless creature (‘zombie’) as he has lost what makes him human: the thinking processes of the brain.

5 Conclusion

We have examined the science behind three of the most popular pseudoscientific beliefs encountered in Hollywood movies. We have shown two of them — the idea of ghosts and vampires — to be inconsistent and contradictory to simple facts. For the third — the idea of zombies — we have made no attempt to deny that it relies on real cases. However, we have reviewed evidence showing that the concept is a misrepresentation of simple criminal acts.

Popular belief in these myths is an indication of a lack of critical thinking skills in our society. With simple arguments one can easily discredit the validity of such claims. We thus finish with the following quote by Carl Sagan [Sagan 1979]:

Both Barnum and H.L. Mencken are said to have made the depressing observation that no one ever lost money by underestimating the intelligence of the American Public. The remark has worldwide application. But the lack is not intelligence, which is in plentiful supply; rather, the scarce commodity is systematic training in critical thinking.

References

- [BBC 2001] *Palace Ghost Laid to Rest*, BBC News, Thursday, 29 March, 2001, <http://news.bbc.co.uk/2/hi/uk/1249366.stm>.
- [Bolemon] JAY BOLEMON, *A Window to Our World*, 2003.
- [Clark 2002] Episode *Zombies—The Living Dead?* from the *Arthur Clarke’s Mysterious Universe*, DVD, American Home Treasures 2002.
- [Furrow 2001] BRYANT FURLOW, *The freelance poisoner*, New Scientist, issue 2274, 20 January 2001.

- [Kirkpatrick & Francis 2007] LARRY D. KIRKPATRICK, GREGORY E. FRANCIS, *PHYSICS, A WORLD VIEW*, 6th ed., Thomson 2007.
- [Sagan 1979] CARL SAGAN, *Boca's Brain: reflections on the romance of science*, Ballantine Publishing Group 1979, p. 58.
- [Sparks 1998] GLENN G. SPARKS, *Paranormal Depictions in the Media: how do they affect what people believe?*, *Skeptical Inquirer*, July/August 1998, p. 35.
- [Sparks 2006] GLENN G. SPARKS, *Media Effects Research: A basic overview*, 2nd ed., Thomson 2006.
- [US Census] U.S. Census Bureau, <http://www.census.gov>.
- [US FDA] U.S. Food & Drug Administration, <http://vm.cfsan.fda.gov/%7Emow/chap39.html>